Saskatchewan
Research Council

A SNOWPACK AND WATER QUALITY SURVEY OF SEVERAL SMALL LAKES IN THE SOUTHWEST PRECAMBRIAN SHIELD AREA OF THE NORTHWEST TERRITORIES: AN ACID DEPOSITION APPROACH

by

S.R. Shewchuk

SRC Technical Report No. 171

Publication E-906-31-B-84

September, 1984

A SNOWPACK AND WATER QUALITY SURVEY OF SEVERAL SMALL LAKES IN THE SOUTHWEST PRECAMBRIAN SHIELD AREA OF THE NORTHWEST TERRITORIES: AN ACID DEPOSITION APPROACH

by

S.R. Shewchuk

SRC Technical Report No. 171

E-906-31-B-84 September, 1984

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	(i)
SUMMARY	(v)
INTRODUCTION	1
PROCEDURES	4
RESULTS	6
CONCLUSIONS	13
REFERENCES	17
APPENDIX	26

LIST OF FIGURES

Figure		Page
1	The location within the Northwest Territories where the 1983-84 acidic deposition study took place	19
2	Location of the Snowbird and Sid Lake sites	20
3	Location of the Kipling and Porter Lake sites	21
4	Location of the Lady Grey and Buffalo Lake sites	22
5	The daily max-min temperature and precipitation structure of Fort Reliance during the study period (data from Environment Canada)	23
6	Mean snow chemistry parameters	24
7	A summary of lake chemistry data from the laboratory analysis for the study area	25

LIST OF TABLES

		Page
Table 1.	Coordinate locations of the small lake sites used for the March 1984 acid deposition study.	9
Table 2.	Mean values of the snowmelt chemistry parameters	10
Table 3.	Sulphate deposition to each lake site.	11
Table 4.	Major cation and anion distribution in the snowmelt water all values in μ eq/L.	12

ACKNOWLEDGEMENTS

This research project was carried out under contract with the Pollution Control Division of the Department of Renewable Resources of the Government of the Northwest Territories. I would like to thank Mr. Mel Smith for providing this contract and for his many helpful suggestions during the execution of this work. In addition, Mr. Lorne James of the Department of Renewable Resources provided many very useful comments on the review phase of this report.

A special thank you must be given to Mr. Bob MacPherson who is a Saskatchewan Research Council employee. Bob's singularly high degree of skill in navigating a light aircraft into the small lakes of the project area of the Northwest Territories was simply first class. He has made this project possible. Field assistance during this work was provided by Ray Begrand of the Saskatchewan Research Council. To all of these individuals, I appreciate quite sincerely all of your interest and assistance in this project.

SUMMARY

A snow chemistry and lake water survey was conducted in March, 1984, to study the acid deposition processes to the snowpack of the southwestern Precambrian Shield in the Northwest Territories. Total sulphate deposition to the Precambrian area in this study was considered quite low and typical of a natural background value. Most acidity measurements indicated that the site locations are experiencing a low level of acid deposition. It is felt that the source of this acidity is either an organic acid, likely from the natural ecosystem, or from an artifact due to the low conductivity of the solutions found or a possible residue deposition of sulphur from the Arctic haze aerosol. There is, however, no indication of the Arctic haze aerosol build-up in the snowpack of this area with regard to metals deposition to the limit of detection of an inductively coupled plasma emission spectrometer (ppb level).

All of the Precambrian Shield lake sites; with the exception of fringe of shield lakes, monitored in this study, are sensitive to acid deposition. Most lake sites have water pH values just above pH 7.0. There is little direct acidification of the area at present. However, with low levels of alkalinity, these lakes are highly sensitive to acid deposition.

INTRODUCTION

The chemistry of snowpacks has been used for many years to assess the impacts of natural and anthropogenic acid deposition. The monitoring of stable (non-melting) snowpacks for major ions and metals can give an excellent assessment of the impacts to be expected on the entire ecosystem.

Snow crystals are nucleated in the atmosphere by submicron size particles. Other particles can be collected by the crystals during their growth. Attachment of impurities may take place by scavenging as the snow crystals move through the atmosphere. This is wet deposition. Between snowstorms, dry atmospheric fallout can add to impurities contained on the surface of the snowcover.

Soluble impurities in the snow are leached out very quickly with the first thawing of the snowpack. Thus a snowpack can store and suddenly release chemical species that can do considerable environmental damage. The process of impurity movement through snow has been described in detail by Colbeck (1981).

Acidity profiles of ice cores taken from the Greenland ice sheet have revealed large volcanic eruptions in the northern hemisphere during the past 10,000 years (Hammer et al, 1980). It is well known that a history of air pollution chemistry is locked in the ice chemistry of the northern regions. Acid concentrations in an ice core from Ellesmere Island representing the past 5,000 years of deposition was studied by Koerner et al, 1982. They were able to compare the snow chemistry of the later period with the past 25 years. Significantly higher concentrations of acid were deposited in the snow over the past 25 years at the same location.

Within the Northwest Territories a large portion of the yearly pre-

cipitation falls as snow. The pollutants contained in the precipitation accumulate in the snow to be released during short periods in spring. During a winter with little or no snowmelt before spring, most of the pollutant load is retained in the snowpack. Accordingly, approximately 50-80% of the pollutant is released in the first 30 percent of meltwater (Johannessen et al, 1978). Snowpack accumulation is a natural method of studying air pollution deposition in this area of Canada.

It is known that freshwater lakes in ecosystems that are lightly buffered are sensitive to acid deposition. There has been much documentation of severe biological consequences in lakes that have been gradually acidified (Harvey, 1979). Most major fish production lakes are quite large and are fed by smaller headwater streams and small lakes. Lake acidification begins initially with small lakes and water bodies of the drainage basin. The acid substances subsequently flow into the larger water bodies. The study of acidification of the environment concentrates major effort on the small lakes. This study will include both the collection of snow for atmospheric depositional chemistry purposes, and lake water from the small lakes which serve as sites for the snow quality study. Once impacts to small lakes are addressed, other portions of the ecosystems of interest to the Northwest Territories can be considered. For example, impacts on lichen communities of acidic precipitation and metals fallout is of importance. It is shown that the lichen communities (Shewchuk, 1983-A) on the Precambrian Shield portion of the mainland Northwest Territories are highly sensitive to acid deposition. Many studies show that long-range transport of air pollution is entering the Northwest Territories from various continental sources (Hileman, 1983 and Barrie et al., 1981). The form of this

aerosol is that either of an acid sulphate or carbon black particle. This air pollution is capable of providing impacts to these ecosystems. The prime reason for transport is the significant reduction in scavenging efficiencies of precipitation during the winter months. Local sources of anthropogenic pollution for the Precambrian areas of the Northwest Territories are the major oil sands and smelter emitters in the provinces (Shewchuk 1983-A). For the Arctic islands, it appears that the trans-continental Eurasian area (Barrie and Hoff 1984, and Shewchuk 1984) represent significant sources of air pollution, particularly during the period of the Arctic winter. These sources are responsible for the recent phenomenon of Arctic haze. Rahn et al (1980) has studied the aerosol composition of Arctic haze and finds a particularly high signature of the metals ratio of mn/v that is typical of the smelters of transcontinental sources.

A light aircraft was flown into the southwest portion of the District of MacKenzie just prior to major snowmelt occurrance of the year 1983-84. Deposited snow and lake water was collected from six small lakes. The principle objectives of this research project were to:

a) collect snow cores and determine the current state of acidification;

b) collect lake water samples and analyse them for major inorganic ions.

PROCEDURES

The study area for this project is shown in Figure 1. The area of the Northwest Territories shown represents a part of the Precambrian Shield that is in close proximity to major southern emitters. Six small lakes representing approximately 200,000 sq. km of land area were selected for the study. The locations of each of these lakes is given in Table 1. A ski-equipped Cessna 185 aircraft was used to service the area. A detailed sketch map of the individual lake sites is shown in Figures 2 to 4. A site consists of a small lake with an area typically of one kilometre square. The name of the lake site is given by the name of the closest major lake water body. Thus, throughout this report, while a lake site is identified by its nearest major lake, the specific site identified in the figures was used to collect snowcores and lakewater.

A sampling site must be considered regionally representative. There must be no local topographic irregularities in the area. The field part of this study took place between March 26-29, 1984. The aircraft flew out of Stony Rapids and serviced the sites in the following order: Snowbird, Sid, Kipling, Porter, Lady Grey and Buffalo. All lake sites are considered on the Precambrian Shield except Buffalo. After the aircraft had landed on the small lake, three snowcores were taken for analysis. Two lakewater samples were taken as well, one for inorganic ions and one for metals. The latter was acidified with a dilute solution of nitric acid. The snow bags were to remain frozen prior to analysis. The lakewater samples were routinely analyzed within a few days of collection.

All metals analyzed in the snowmelt and lakewater samples except arsenic and mercury were measured to the ppb range with an inductively coupled plasma emission spectrometer (Jarell-Ash Model 1140: ICP-AES). Arsenic was (detection limit 0.5 ppb) analyzed with an atomic absorption spectrometer with a hydride generation system (MAS-10). Mercury was analyzed with a Fischer mercury analyzer to detection limit of 0.05 ppb. Major anions were measured with a Dionex System 12 Ion Chromatograph. Most acidity determinations and pH were performed by titration as this method was considered most appropriate for dilute solutions of environmental samples (MacQuaker et al, 1983). A Mettler DL40 automatic titrator was used for all the samples. Nitrate was measured by cadmium-reduction techniques and ammonia was measured by titration techniques. All nitrate and ammonia concentrations are expressed as nitrogen only.

RESULTS

The daily max-min temperature structure of Fort Reliance is shown in Figure 5. The purpose of this Figure was to show that during the winter period the snow remained frozen throughout the entire season. Any major snowmelt would have had a leaching effect on the major ions in the snow and no conclusions with regard to atmospheric particulate deposition could be drawn. The snowpack from this field season has remained quite stable throughout the entire period.

Table 2 is a summary of the snowmelt parameters from each of the sites. It is interesting to point out that most of the alkaline earth metals (Ca, K, Mg and Na) are very near the detection limits of our analytical procedures. In addition, bicarbonate, chloride and ammonia are at consistently low levels. Sulphate and nitrate are quite low on the Shield. They increase at Buffalo Lake and at the one off-Shield site. An exception to this is Sid Lake with a value of sulphate and nitrate at nearly double what is to be expected for the southwest Precambrian Shield areas of the Northwest Territories. The snow pH at most of the Precambrian Shield sites is below 5.6., whereas on fringe-Shield (Lady Grey) and off-Shield (Buffalo) sites the pH of the snow is above 5.6.

The results from the snow chemistry at each site are shown in Figure 6. Four main parameters used to classify the snow quality are sulphate (mg/L), pH, calcium (mg/L) and nitrate (mg/L). Most values quoted represent averages of three snowcores. The exceptions were at Porter and Snowbird where two samples were used and Lady Grey, where one sample was used in the analysis. Contaminated snowcores were identified by

examination of the amount of analyzed calcium in the core. If the amount of calcium was above a specified value (see Table 2), the snowcore was said to be contaminated. The single greatest source of this contamination was considered to be the collection of white ice in with the snow sample. White ice forms at the intersection of the snowpack and the flooded lake surface.

The atmospheric deposition to the snowpack of the area is shown in Table 3. The deposition was calculated as the product of the mean sulphate concentration of the cores and the equivalent water depth. The equivalent water depth was determined by taking the meltwater from the core and dividing by the area of the cover. The deposition to the snowpack ranges from 67 to 14 mg/m^2 of sulphate. It is seen that most of the sites on the Precambrian Shield area have a uniform and quite low level of sulphate deposition. Table 4 shows the cation and anion balance for the sites located at Buffalo, Sid and Snowbird. The most significant feature of these balances was the rather low concentrations of virtually all major ions. Metals such as potassium and magnesium were below the detection limits of our analytical procedures (<4 μ eq/L). The major cations are seen to be calcium, sodium and hydrogen. The major anions are sulphate and bicarbonate. The highest bicarbonate and sulphate comes from the Buffalo Lake site.

There were twenty-three major trace metals determined in the snow cores from each lake, some of which included: Al, Be, Cd, Co, Cr, Mn, Ni, Pb, V, Ti and Zn. All these metals were below the 5 ppb range. Both manganese and vanadium were consistently below the detection limits of the ICP-AES analysis.

The laboratory analyzed lake water chemistry data is summarized for the parameters of interest in Figure 7. A more complete presentation of the data available is shown in the Appendix. At Buffalo Lake no water sample was collected due to the fact that the aircraft was landed on a small lake in the area that had frozen completely to the sediment surface. The lowest pH value as determined by laboratory analysis was 7.41 from the Snowbird area. The low alkalinity values indicate that all lakes in the study area except Lady Grey are sensitive to acid input to some extent. The high alkalinity of Lady Grey indicates some strong bicarbonate influence on the lake, likely from the sediment transport from off-Shield areas. Lake sediment derived calcium is present in all of the Precambrian Shield lakes in great abundance.

Table 1. Coordinate locations of the small lake sites used for the March 1984 acid deposition study.

Lake Area	Latitude	Longitude
Snowbird Lake Area	60° 42"	103° 07"
Sid Lake	62° 19"	103° 51"
Kipling Lake	62° 47"	108° 36"
Porter Lake Area	61° 44"	108° 13"
Lady Grey Lake Area	60° 52"	110° 26"
Buffalo Lake Area	60° 25"	114° 56"

Table 2. Mean values of the snowmelt chemistry parameters

Site Area	SO_4 (mg/L)	N(ammonia) (mg/L)	$N(NO_3)$ (mg/L)	Cl (mg/L)	HCO_3 (mg/L)	K (mg/L)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	Specific Conductivity (μmhos/cm)	pH
Snowbird	0.34	0.03	0.075	0.09	0.3	<0.2	<0.2	<0.06	<0.05	6	5.2
Sid	0.72	0.03	0.100	0.06	0.7	<0.2	<0.2	0.11	<0.05	9	5.0
Kipling	0.36	0.02	0.057	0.13	0.8	<0.2	0.4	0.12	<0.05	5	5.4
Porter	0.36	0.01	0.062	0.08	0.6	<0.2	<0.2	0.11	<0.05	5	5.0
Lady Grey	0.21	0.03	0.068	0.05	0.9	<0.2	<0.2	0.09	<0.05	4	6.4
Buffalo	0.86	0.03	0.076	0.04	0.7	<0.2	0.4	0.13	<0.05	5	5.9

Table 3. Sulphate deposition to each of the lake sites.

Lake	Snow Depth (cm)	Equivalent Water Depth (cm)	SO_4 (mg/L)	Deposition (mg/m^2)
Porter	34	6.7	0.36	24
Snowbird	20	5.3	0.34	18
Lady Grey	28	6.6	0.21	14
Sid	26	8.4	0.72	61
Kipling	28	7.3	0.36	26
Buffalo	30	7.8	0.86	67

Table 4. The major cation and anion distribution in the snowmelt water all values in μ eq/L.

Cation	Buffalo	Sid	Snowbird
Ca	7	6	4
Na	17	13	6
$N(NH_3)$	2	2	1
H	2	10	6
TOTAL	28	31	17

Anion	Buffalo	Sid	Snowbird
Cl	1	2	3
HCO_3	11	7	5
SO_4	18	15	7
$N(NO_3)$	5	7	6
	35	31	21

CONCLUSIONS

The sulphate concentrations on the Precambrian Shield snowcores indicate that depositions at the present time are at or near a "background value" however some form of acidity is present in the snowpack. Several research workers (Hammer et al., 1980, Koerner et al., 1982) have found that sulphate concentrations in the ice cores of Greenland in the absences of major volcanic emissions were in the range of 0.10 to 0.30 mg/L. During volcanic eruptions atmopsheric deposition to the glaciers usually produces sulphate concentrations in excess of 0.30 mg/L. Several authors have quoted background sulphate deposition values to the snow of <200 mg/m^2 with episodic events in the snow deposition occurring and values as high as 600 mg/m^2 (Johannessen et al., 1975). For this area sulphate deposition was significantly less than these values.

The anomaly of high sulphate and nitrate at Sid Lake is not typical of the Precambrian Shield of this area studied. It is also significant to note that the pH of the snow of this site is 5.0. This implies that some form of acidity is present in the snow. The studies were not conducted beyond Sid Lake therefore we have no idea as to how far this influence may extend. Sites north of this point are more likely to receive Arctic haze aerosol influences. At this time we must treat Sid Lake as a local anomaly in the data field. It is suggested that studies be conducted beyond this site to the north and east to confirm this. Background sulphate deposition to the sites on the study area of the Precambrian Shield during this field season were typically 20 mg/m^2, significantly lower than what is expected from areas where acid deposition is an environmental problem. However, this area of Canada is highly sensitive to

acid deposition. It is quite likely that even marginal increases in acid deposition above a "background value" will result in perceptible impacts. The specific conductivity of the melted snow being in the order of 4 to 9 μmhos per cm suggests the snow is near the conductivity of laboratory grade distilled water.

The low pH values in the snow of most Precambrian snowcores is of interest. Natural snow under the influence of a carbon dioxide control has a pH of 5.6. Recent work by several authors (Keene et al., 1983 and Shewchuk 1983-B) has shown that remote areas of the world can have values of pH that are significantly below 5.6. The exact source of the acidity is not known. It is well known that the conductivity of very dilute solutions, as we have here, can influence the streaming and liquid junction potentials of normal pH electrodes to produce erroneous results in measuring these solutions (Tyree, 1981). The deposition of sulphate at all of the sites was well within a range that can be considered near background. Nevertheless according to some authors (Barrie et al., 1981) the Arctic haze aerosol could be contributing to acidity. A detailed ion balance of the deposited snow chemistry does show that sulphur derived anions dominate the ion balance in most locations.

It was exceedingly difficult to get a good balance from the major ions present because the solutions were so dilute. Other than the alkaline earth metals, no other metals were found above the 5 ppb range. Neither magnesium nor vanadium were detectable in the snowcores. The snow crystals falling onto the snowpack of this area of the Northwest Territories are clearly not scavenging out the heavy metals to any significant degree which are typical of industrial emitters contributing to the Arctic haze phenomenon.

Since all of the small lakes sampled represent headwater systems to major water systems, first impacts of lake acidification will show up here. The fact that virtually all of the lake water sampled were slightly alkaline indicates that little acidification of the aquatic systems is taking place in this area. Most lakes on the Precambrian Shield portion of the study area are sensitive to acid deposition based on alkalinity system of criteria. However, fringe Shield lakes such as Lady Grey are well buffered with high alkalinities present.

Recommendations for future work include extending this survey study into the area north and east of the present area. The area studied in this project represents only a small portion of the Precambrian Shield of the Northwest Territories. Areas such as Ennadai and Kaminak Lakes are likely highly sensitive to acid deposition and lie even closer to the anthropogenic emitters of northern Manitoba. The chemical composition of the snow and the lake water in and around Baker Lake is of interest. It is likely that the areas immediately north of Baker Lake into the Melville Peninsula will show some impacts in the snow quality due to the Arctic haze phenomenon as reported earlier. In Igloolik, where Environment Canada has established a monitoring site, (Barrie and Hoff 1984) impacts on air quality have been observed. Extensive studies of the composition of snow in different parts of the Arctic could provide interesting details on the distribution of sources and sinks in the area. In addition, a more complete environmental data base is needed for this area of the Northwest Territories if sensitivity mappings are to be completed for both precipitation (rain and snow) and lake waters.

Finally, it is of interest to continue monitoring the sites already established on our data base of the Northwest Territories for several years as this will allow the collection of sufficient data to understand the long-term variability of the chemical quality of the environment in this area.

Over the course of a winter, acids precipitated from the atmosphere build up in the snowpacks. All acidic and alkaline species remain in the snowpack until melting. During the spring thaw, the sudden release of these acids can cause rapid temporary acidity stresses on the environment. The Precambrian Shield portion of the Northwest Territories is particularly sensitive to these stresses. This report confirms the high sensitivities for the southwest portion of the MacKenzie District and indicates that the current levels of acid deposition from the atmosphere are low. It is of interest now to extend this study into other areas of the Northwest Territories to determine the spacial extent of acid deposition from the Arctic haze phenomenon. An even marginal increase to these deposition values may have significant deliterious impacts upon the environment of this very important region of Canada.

REFERENCES

Barrie, L.A. and R.M. Hoff 1984. Results of five years of air chemistry studies in the Canadian Arctic. Third Symposium on Arctic Air Chemistry, May 7-9, 1984, Downsview, Ontario.

Barrie, L.A. and R.M. Hoff and S.M. Daggupaty 1981. The influence of mid-latitude pollution sources on haze in the Canadian Arctic. Atmospheric Environment 15, pp. 1407-1419.

Colbeck, S.C. 1981. A simulation of the enrichment of atmospheric pollutants in snow cover runoff. Water Resources Research 17, 5 pp. 1383-1388.

Hammer, C.U., H.B. Clausen and W. Dansgaard, 1980. Greenland ice sheet evidence of post-glacial volcanism. Nature 288, p. 230-235.

Harvey, H.H., 1979. The acid deposition problem and the emerging research need in the toxicology of fishes. Proc. 5th Annual aquatic Toxicity Workshop. Hamiltion, Ontario, No.v 7-9, 1978. Fish Mar. Serv. Tech. Rep. 862. pp. 115-128.

Hileman, B., 1983. Arctic haze. Environmental Science and Technology 17, 6. pp. 232A-236A.

Johannessen, M., T. Dale, E.T. Gjessing, A. Henriksen and R.F. Wright 1975. Acid precipitation in Norway: the regional distribution of contaminants in snow and the chemical concentration processes during snowmelt. Proc. Int. Symp. on Isotopes and Impurities in snow and Ice. Int. Assoc. Hydrol. Sci. Grenoble; France.

Johannessen, M. and A. Hendricksen, 1978. Chemistry of snowmelt: Changes in concentration during melting. Water Resources Research 14, 4 pp. 615-619.

Keene, W.C., J.N. Galloway, and D. Holden, 1983. Measurement of weak organic acidity in precipitation from remote areas of the world. Journal of Geophy. Res. 88 pp. 5122-5130.

Koerner, R.M. and D. Fisher, 1982. Acid snow in the Canadian high Arctic Nature 295, 14, pp. 137-140.

McQuaker, N.R., P.D. Kluckner and D.K. Sandberg, 1983. Chemical analysis of acid precipitation: pH and acidity determinations. Environ. Science Technol. 17, pp. 431-435.

Rahn, K.A. and R.J. McCaffrey, 1980. On the origin and transport of winter Arctic aerosol. Ann. N.Y. Acad. Sci. 388, pp. 486-503.

Shewchuk, S.R., 1983-A. An acid deposition perspective for the Northwest Territories. Science Advisory Board of the Northwest Territories ISBN-0-7708-8116.

Shewchuk, S.R. 1983-B. A snowpack and surface water chemistry survey of small lakes in Northern Saskatchewan. SRC Technical Report No. 155.

Shewchuk, S.R., 1984. Summary notes taken at the Third Symposium on Arctic Air Chemistry, personal communication, Science Advisory Board, Government of the Northwest Territories.

Tyree, S.Y. 1981. Rainwater acidity measurement problems. Atmospheric Environment 5, pp. 57-60.

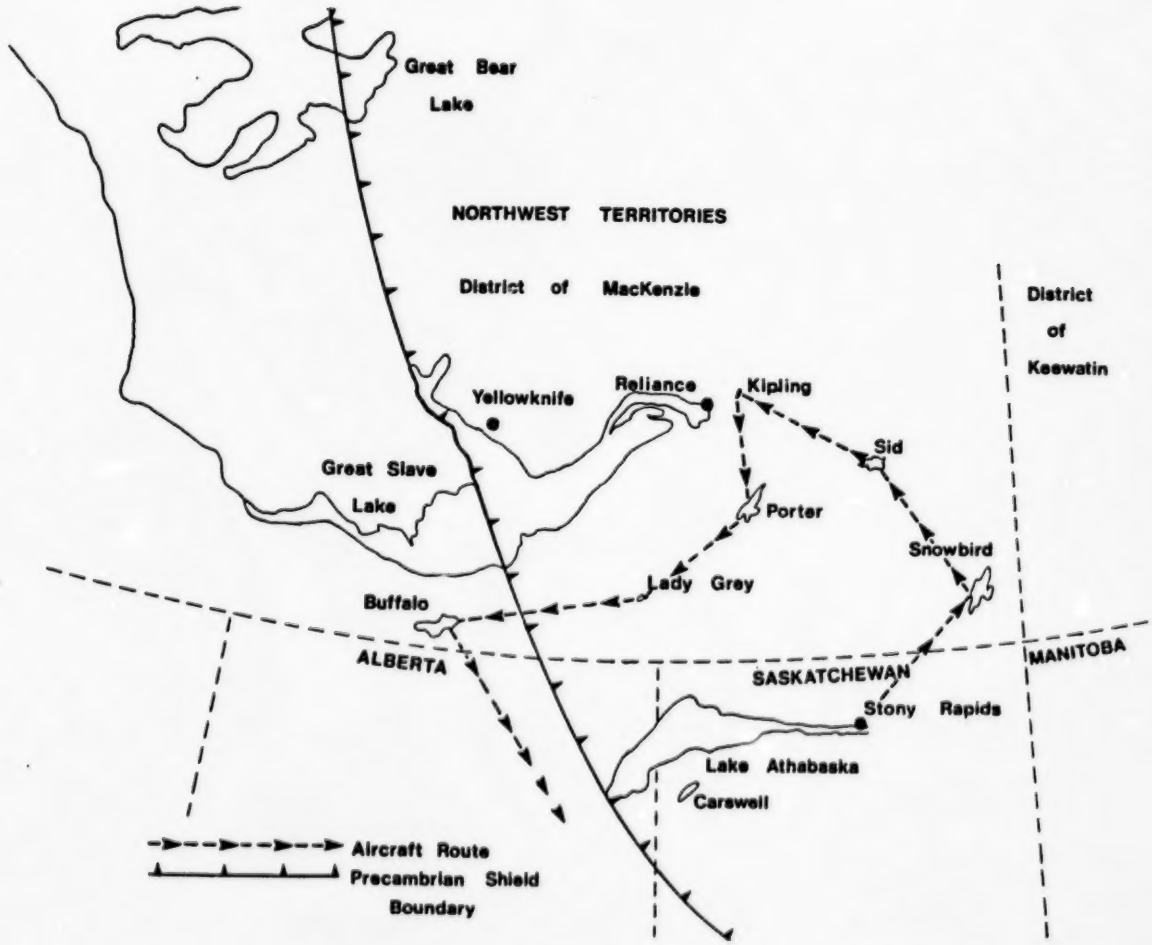

Figure 1. The location within the Northwest Territories where the 1983-84 acidic deposition study took place.

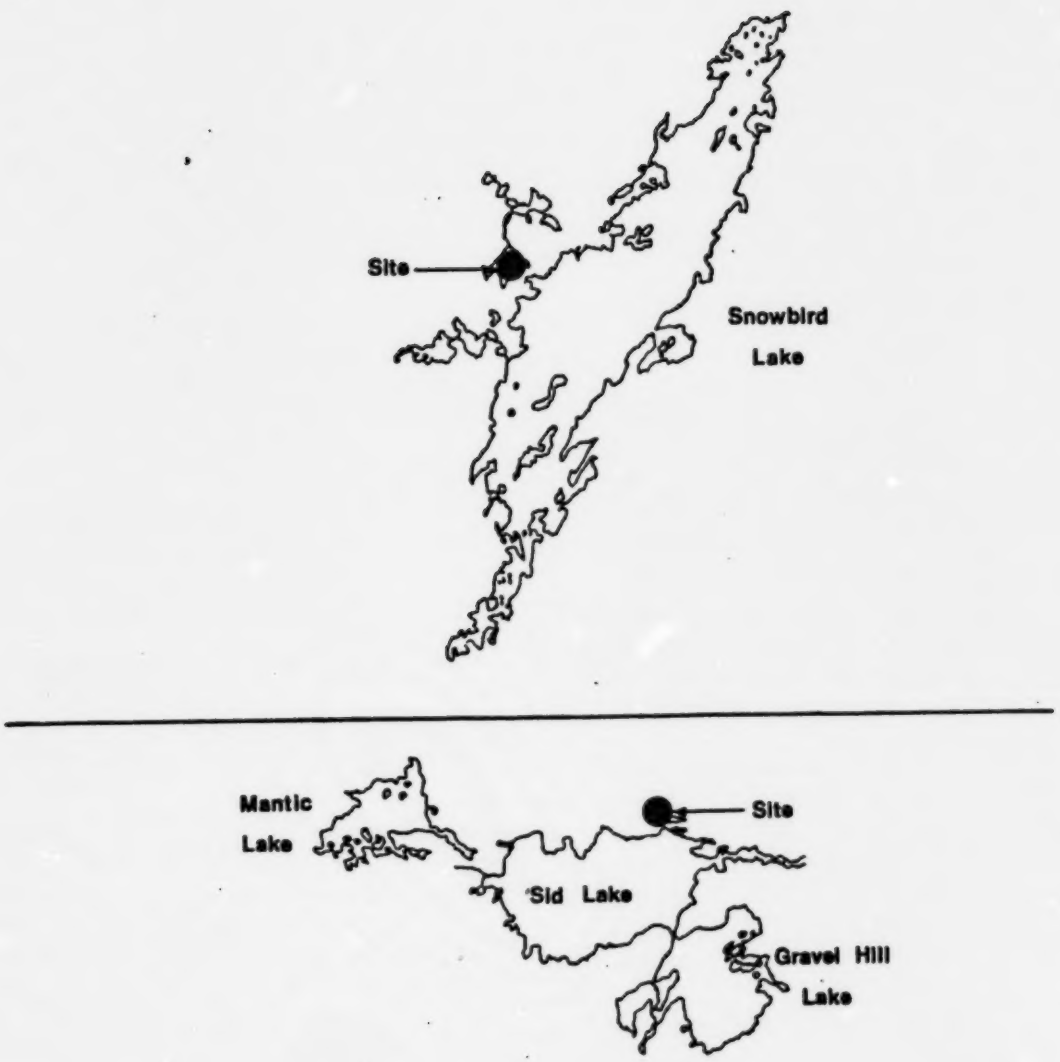

Figure 2. Location of the Snowbird and Sid Lake sites.

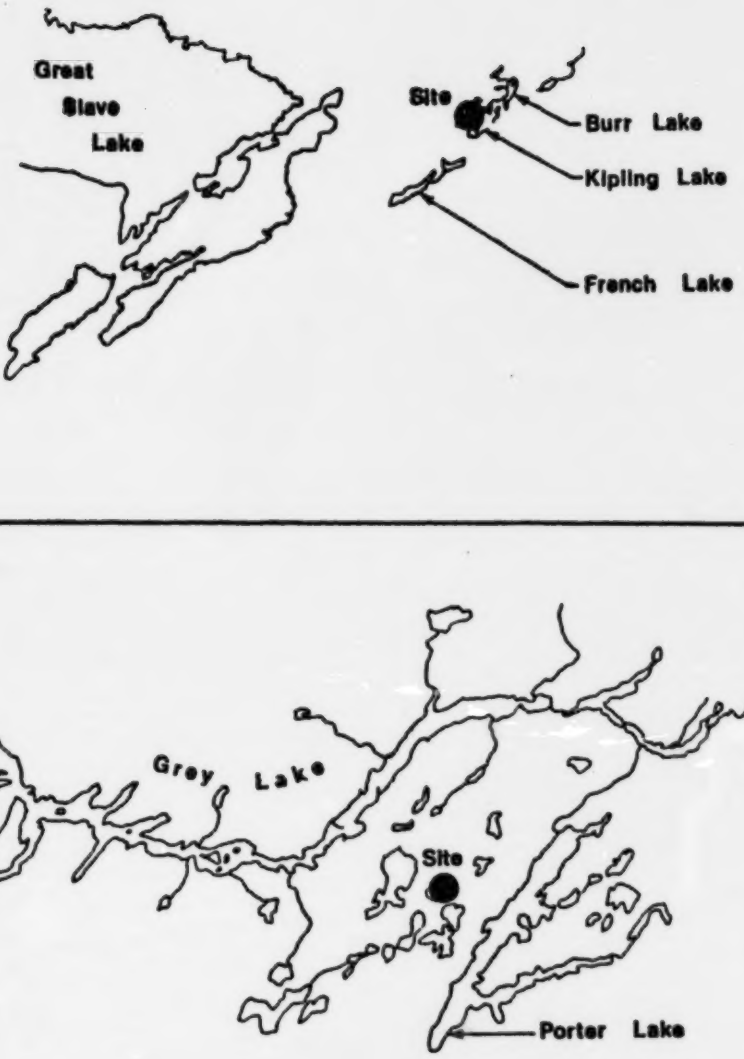

Figure 3. Location of the Kipling and Porter Lake sites.

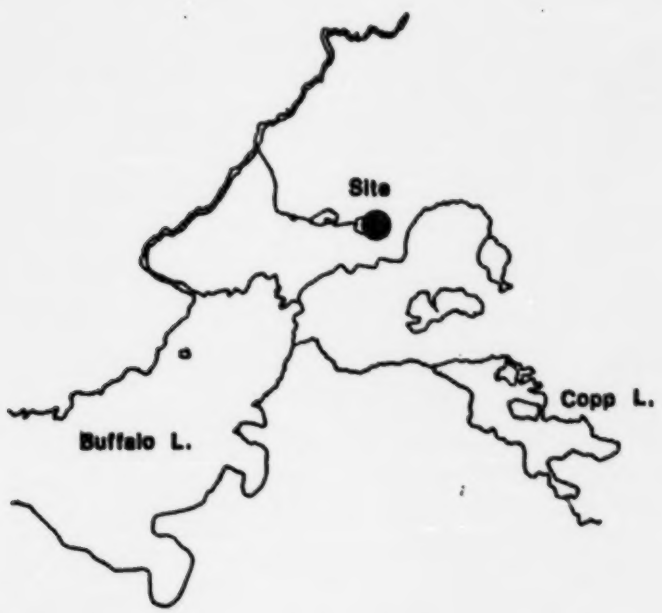

Figure 4. Location of the Lady Grey and Buffalo Lake sites.

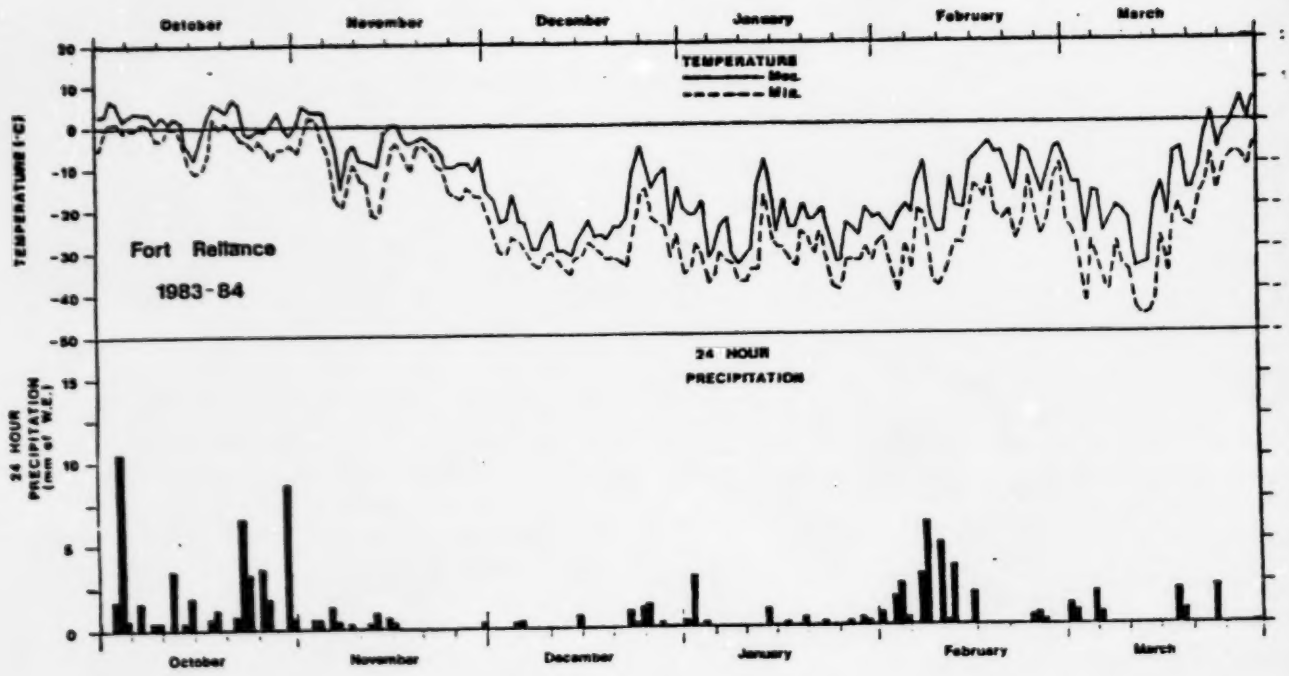

Figure 5. The daily max-min temperature and precipitation structure for Fort Reliance during the study period (data from Environment Canada).

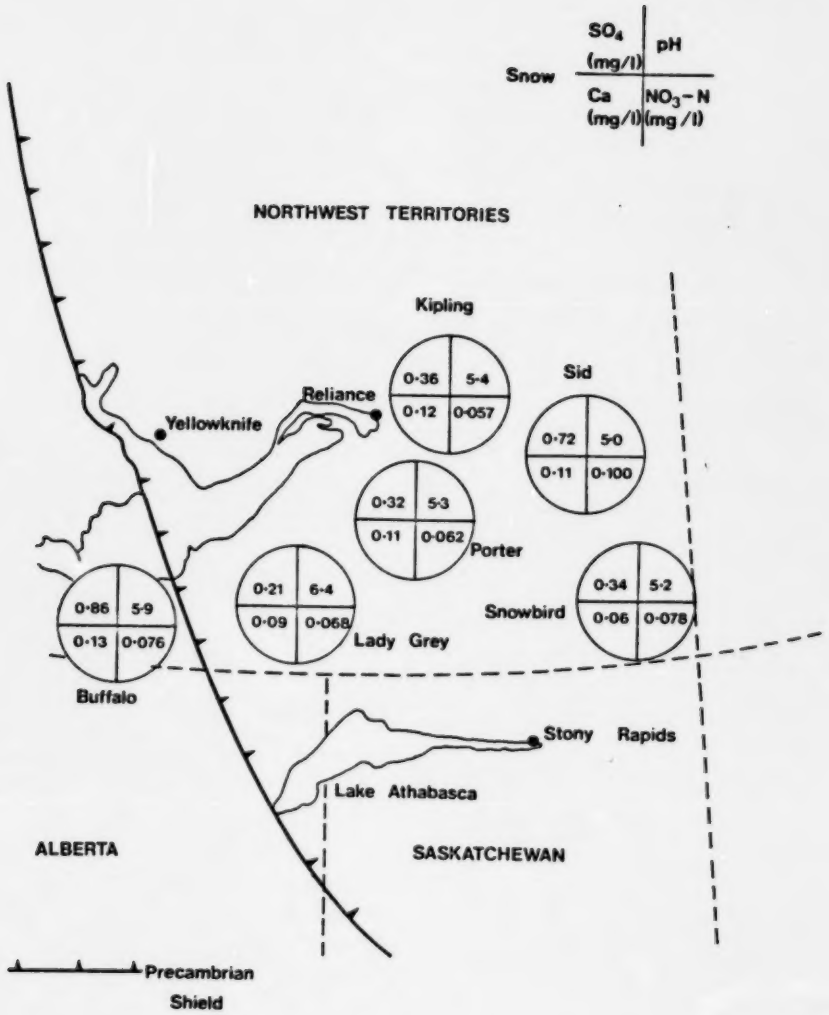

Figure 6. Mean snow chemistry parameters.

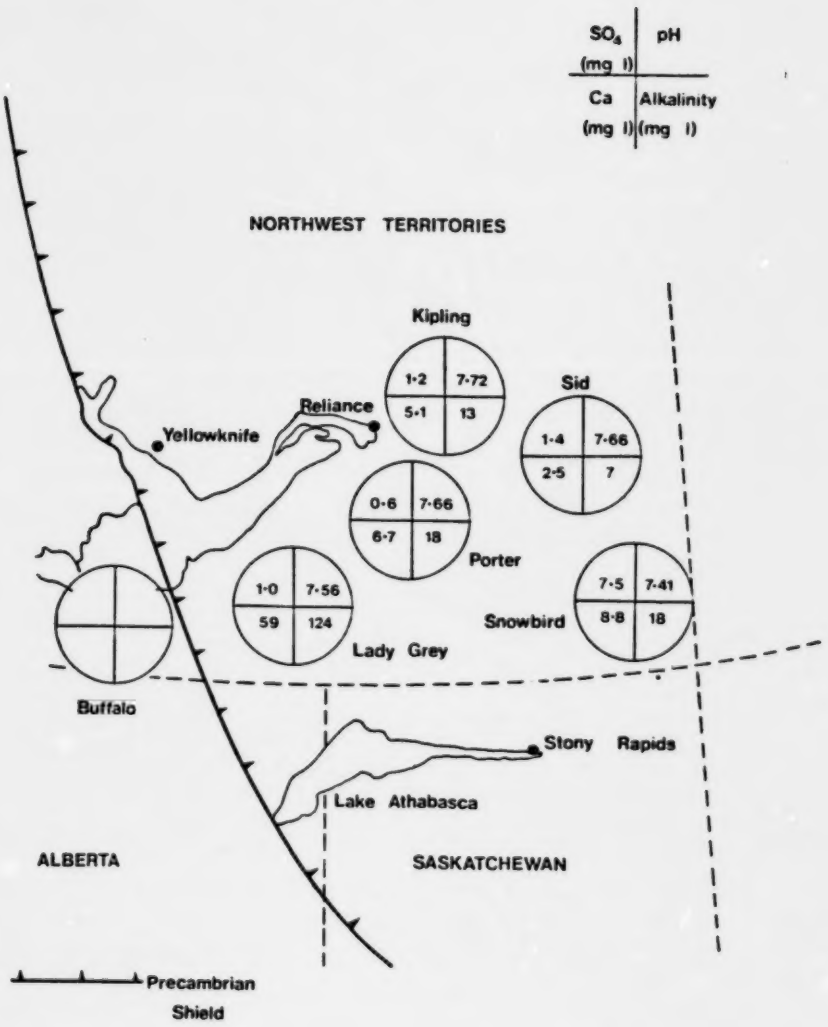

Figure 7. A summary of lake chemistry data from the laboratory analysis for the study area. Please note, lake chemistry sample unobtainable at Buffalo site due to solid freezeup of the small lake.

APPENDIX

Laboratory lake water (inorganic and metals)
chemistry results for the small lakes of this survey

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC
30 Campus Drive
Saskatoon, Saskatchewan S7N 0X1
Attn: S. Shewchuk, E-906-12

MAY 24 '84

Date Samples Received: 05-Apr-84 Client P.O.:

SAMPLE CLIENT DESCRIPTION
3351 SYD L. *WATER*
3352 WEST OF PORTER LAKE *WATER*
3353 NEAR SNOWBIRD *WATER*
3354 EAST OF L. GREY *WATER*

ANALYTE	UNITS	3351	3352	3353	3354
MAJOR CONSTITUENTS					
Cl, ion chrm	mg/L	1.1	0.25	1.0	2.4
HCO3, acid titr	mg/L	8	22	22	151
K, flame	mg/L	0.8	1.6	1.0	3.0
Na, flame	mg/L	0.8	1.1	1.6	4.3
SO4, ion chrm	mg/L	1.4	0.6	7.5	1.0
Tot. Alkalinity	mg/L	7	18	18	124
Tot. Hardness	mg/L	9	22	32	178
NUTRIENTS					
C, tot. inorg.	mg/L	<1	2	4	32
C, tot. org.	mg/L	1	5	21	39
N, Ammonia	mg/L	<0.01	0.06	0.03	2.0
N, NO3 only	mg/L	0.12	0.19	0.14	0.14
N, total Kjeld.	mg/L	0.27	0.42	1.4	2.9
P, total as P	mg/L	<0.01	<0.01	<0.01	<0.01
TRACE CONSTITUENTS					
Acidity, strong	meq/L	NIL	NIL	NIL	NIL
Acidity, weak	meq/L	0.002	0.006	0.016	0.027
B, ICP-AES	mg/L	<0.01	<0.01	<0.01	0.01
Hg, by A.A.	ug/L	<0.05	<0.05	<0.05	<0.05
P, ICP-AES	mg/L	<0.05	<0.05	<0.05	<0.05
TRACE METALS					
Ag, ICP-AES	mg/L	<0.001	<0.001	<0.001	<0.001
Al, ICP-AES	mg/L	0.084	0.017	0.35	0.031
As, hydride gen	ug/L	<0.5	<0.5	<0.5	<0.5
Ba, ICP-AES	mg/L	0.009	0.019	0.038	0.044
Be, ICP-AES	mg/L	<0.001	<0.001	<0.001	<0.001
Ca, ICP-AES	mg/L	2.5	6.7	8.8	59
Cd, ICP-AES	mg/L	<0.001	<0.001	0.002	<0.001
Co, ICP-AES	mg/L	<0.001	<0.001	0.001	<0.001
Cr, ICP-AES	mg/L	0.002	0.002	0.005	0.003
Cu, ICP-AES	mg/L	0.008	0.004	0.014	0.002
Fe, ICP-AES	mg/L	0.12	0.029	1.6	3.8
K, ICP-AES	mg/L	0.8	1.6	1.0	3.0
Mg, ICP-AES	mg/L	0.74	1.2	2.5	7.3
Mn, ICP-AES	mg/L	0.006	0.009	0.12	0.69
Mo, ICP-AES	mg/L	<0.005	<0.005	<0.005	<0.005

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

Na, ICP-AES	mg/L	0.8	1.1	1.6	4.3
Ni, ICP-AES	mg/L	0.001	0.002	0.006	0.002
Pb, ICP-AES	mg/L	0.005	<0.005	0.005	<0.005
Ti, ICP-AES	mg/L	0.004	<0.001	0.021	<0.001
V, ICP-AES	mg/L	<0.01	<0.01	<0.01	<0.01
W, ICP-AES	mg/L	<0.005	<0.005	<0.005	<0.005
Zn, ICP-AES	mg/L	0.021	0.011	0.014	0.018
PHYSICAL PROPERTIES					
Solids, T.Diss.	mg/L	26	42	42	220
Solids, T.Susp.	mg/L	2	<1	11	4
Sp. Conduct.	umho/cm	19	44	49	250
Total Volume	mL	Not req	Not req	Not req	Not req
pH of water	pH units	7.66	7.66	7.41	7.56
pH, grans plot	pH units	Not req	Not req	Not req	Not req

SASKATCHEWAN RESEARCH COUNCIL

MAY 24 '84

Environment Sector, SRC

SAMPLE CLIENT DESCRIPTION
3355 KIPLING L. *WATER*

ANALYTE	UNITS	3355
MAJOR CONSTITUENTS		
Cl, ion chrm	mg/L	1.7
HCO3, acid titr	mg/L	16
K, flame	mg/L	0.6
Na, flame	mg/L	1.0
SO4, ion chrm	mg/L	1.2
Tot. Alkalinity	mg/L	13
Tot. Hardness	mg/L	20
NUTRIENTS		
C, tot. inorg.	mg/L	<1
C, tot. org.	mg/L	3
N, Ammonia	mg/L	<0.01
N, NO3 only	mg/L	0.098
N, total Kjeld.	mg/L	0.12
P, total as P	mg/L	<0.01
TRACE CONSTITUENTS		
Acidity, strong	meq/L	NIL
Acidity, weak	meq/L	0.002
B, ICP-AES	mg/L	0.04
Hg, by A.A.	ug/L	<0.05
P, ICP-AES	mg/L	<0.05
TRACE METALS		
Ag, ICP-AES	mg/L	<0.001
Al, ICP-AES	mg/L	0.048
As, hydride gen	ug/L	<0.5
Ba, ICP-AES	mg/L	0.010
Be, ICP-AES	mg/L	<0.001
Ca, ICP-AES	mg/L	5.1
Cd, ICP-AES	mg/L	<0.001
Co, ICP-AES	mg/L	<0.001
Cr, ICP-AES	mg/L	0.007
Cu, ICP-AES	mg/L	0.056
Fe, ICP-AES	mg/L	0.019
K, ICP-AES	mg/L	0.6
Mg, ICP-AES	mg/L	1.7
Mn, ICP-AES	mg/L	0.003
Mo, ICP-AES	mg/L	<0.005
Na, ICP-AES	mg/L	1.0
Ni, ICP-AES	mg/L	0.002
Pb, ICP-AES	mg/L	<0.005
Ti, ICP-AES	mg/L	<0.001
V, ICP-AES	mg/L	<0.01
W, ICP-AES	mg/L	<0.005
Zn, ICP-AES	mg/L	0.018

SASKATCHEWAN RESEARCH COUNCIL

Environment Sector, SRC

****

PHYSICAL PROPERTIES

Solids, T.Diss.	mg/L	36
Solids, T.Susp.	mg/L	<1
Sp. Conduct.	umho/cm	37
Total Volume	mL	Not req
pH of water	pH units	7.72
pH, grans plot	pH units	Not req

****